



# WESTCARB Regional Partnership

## From Pilots to Deployment

***Larry Myer***

WESTCARB Technical Director  
California Energy Commission  
[lrmeyer@lbl.gov](mailto:lrmeyer@lbl.gov)

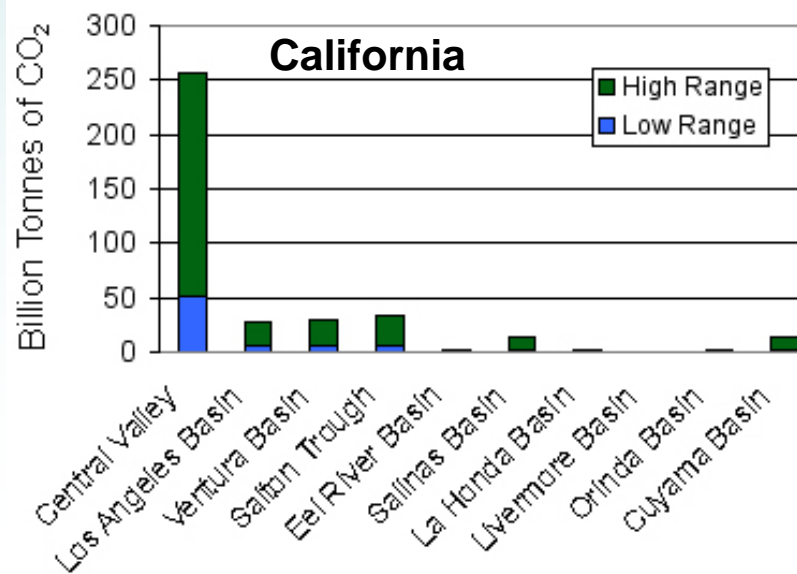
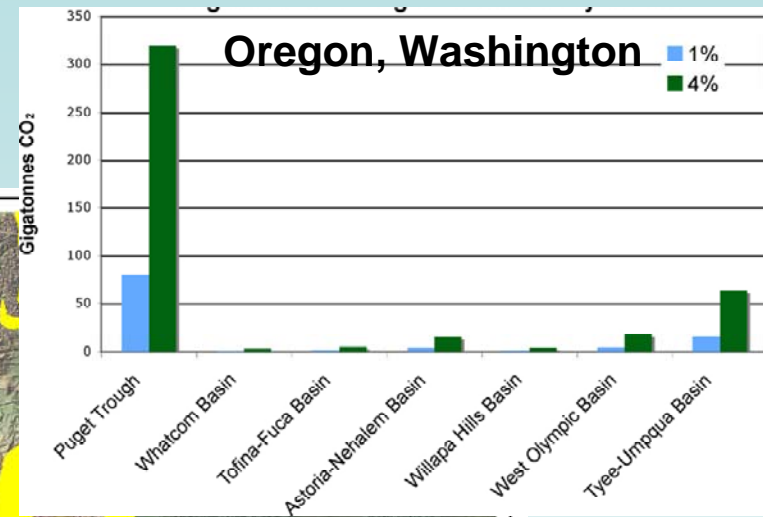
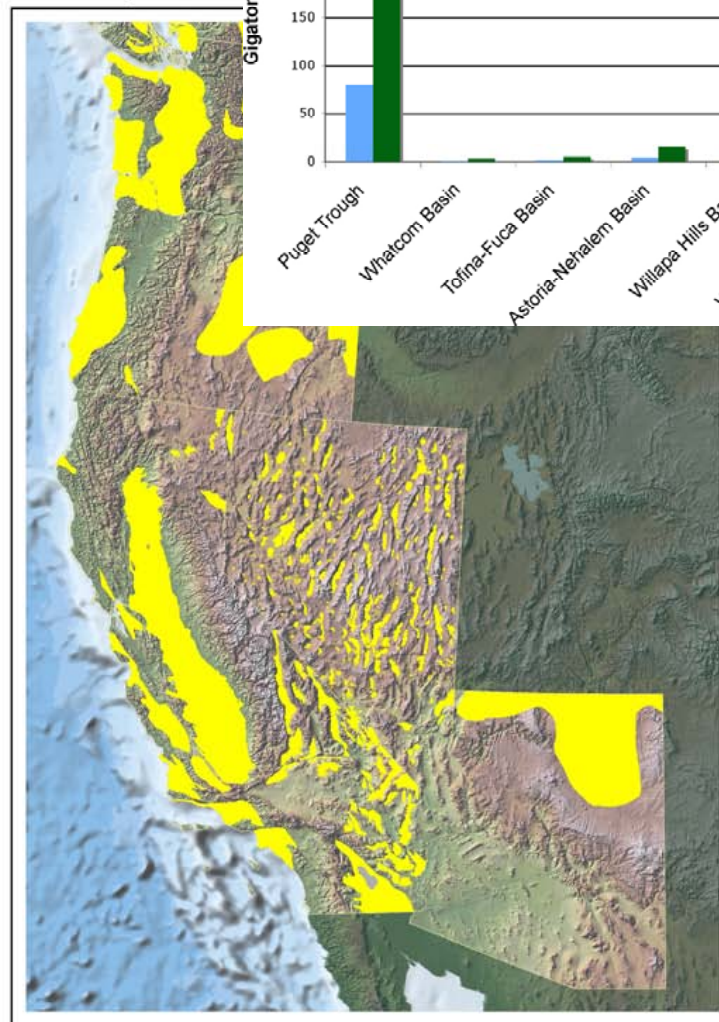
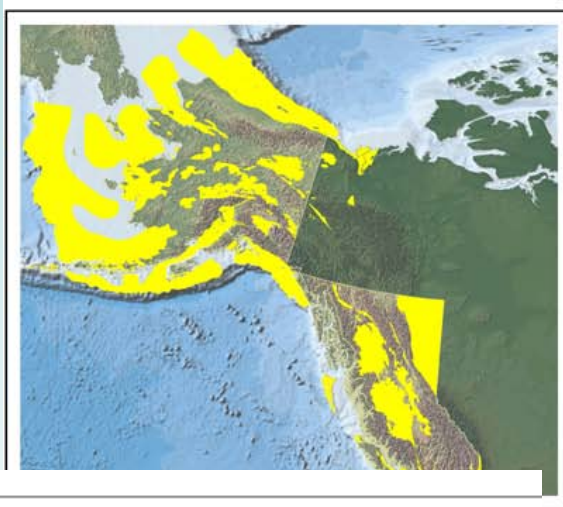
***Terry Surles***

University of Hawaii

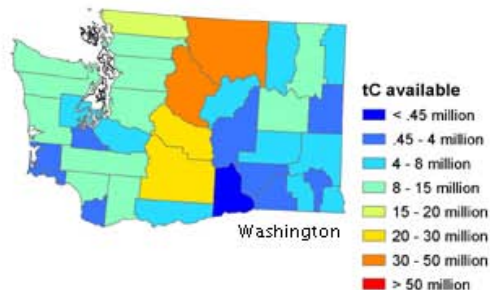
*Pittsburgh, PA  
December 12, 2007*



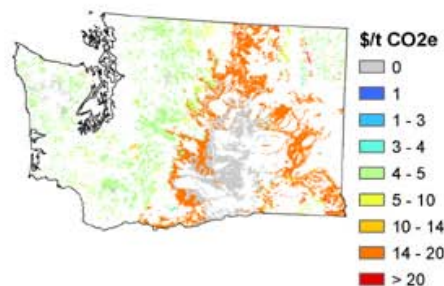
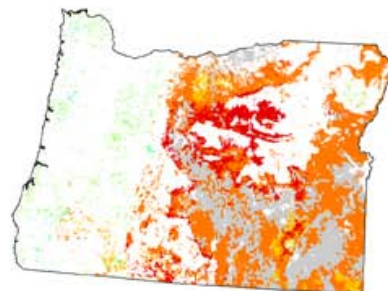
# Continuing Regional Characterization



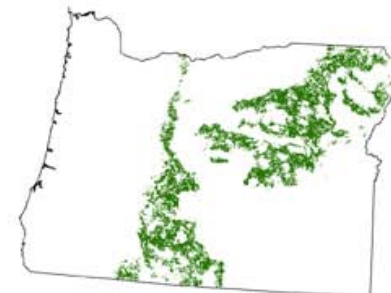
# Afforestation and Fuel Management are Major Terrestrial Opportunities in California



40 year sequestration potential



40 year marginal costs

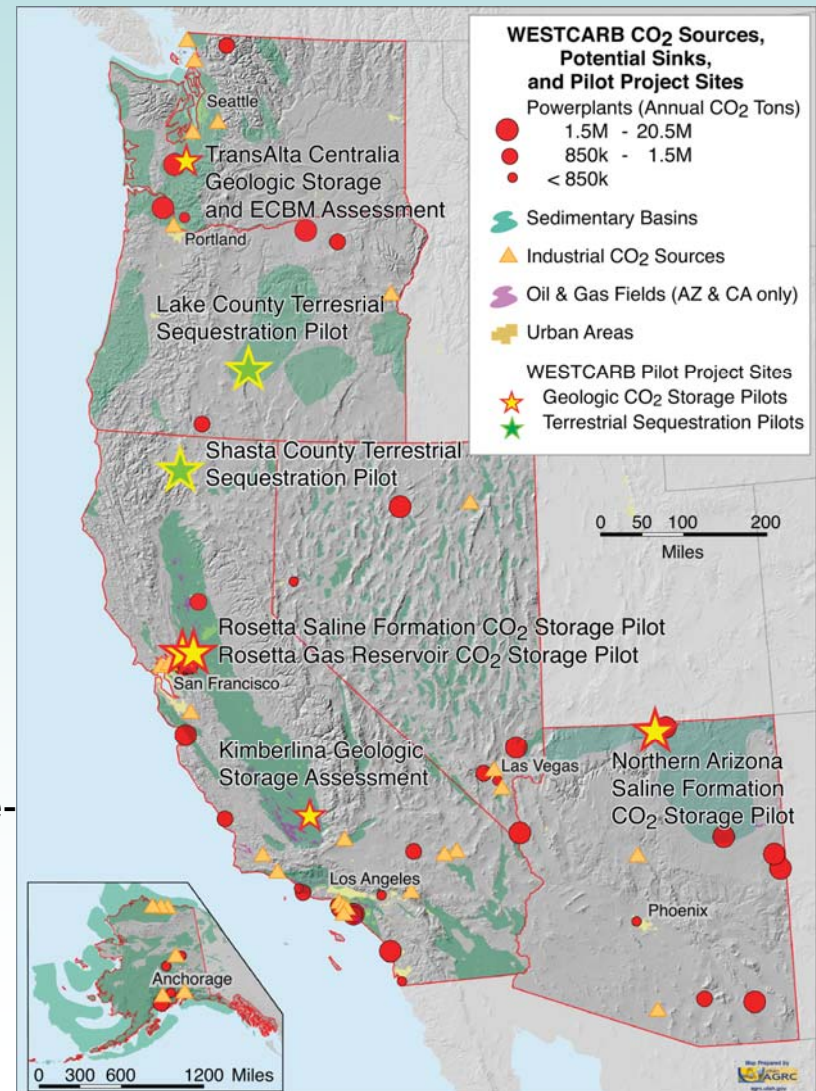


Lands suitable for fuel removal



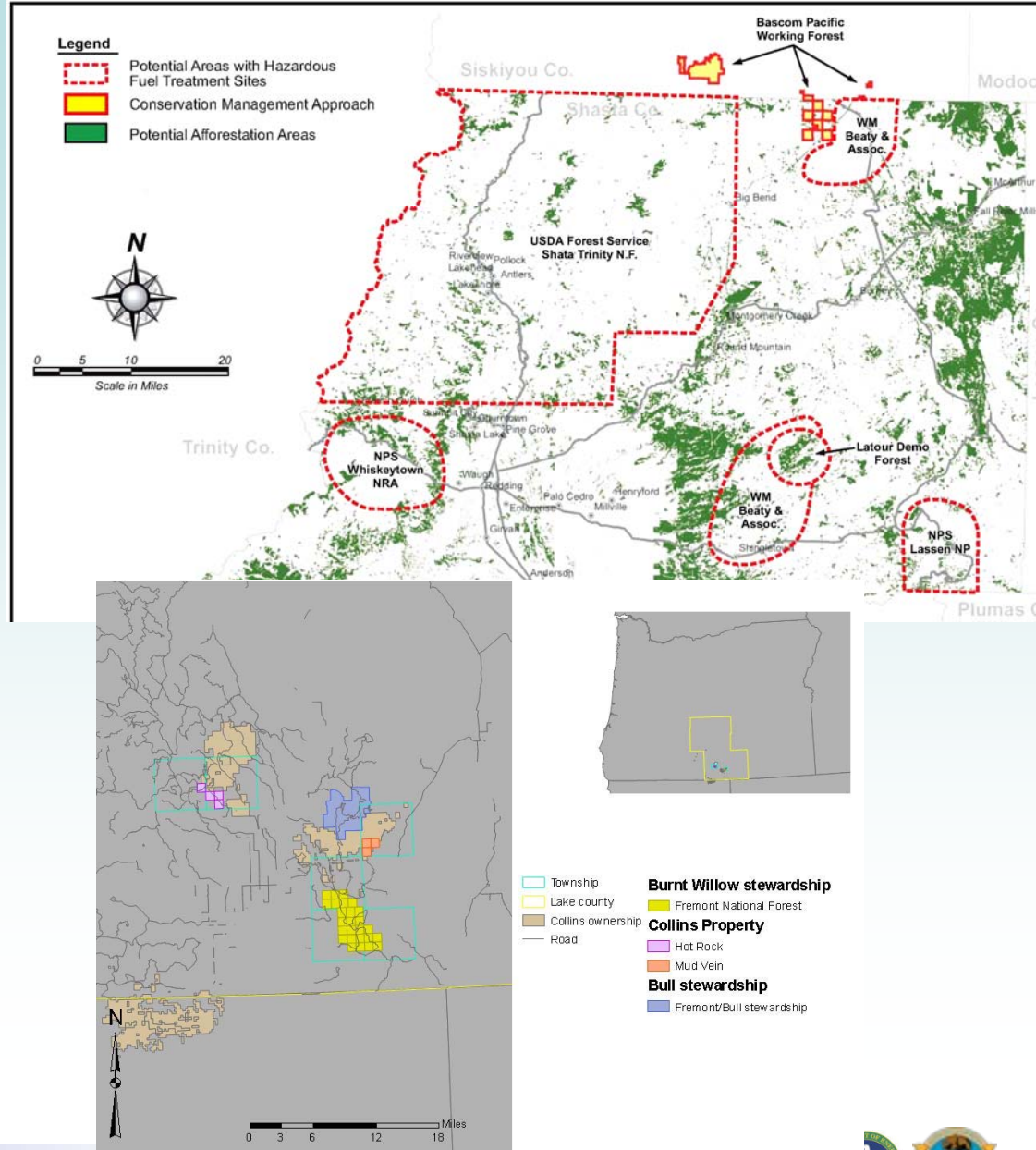
# Field Tests Provide Regional Knowledge Base Essential for Commercial Implementation

- Two injection pilot sites
  - EGR and saline formation injections in Thornton, CA
  - Saline formation injection in northeast AZ
- Two “site characterization” pilots
  - ECBM/saline in Centralia, WA
  - EOR/saline in Kimberlina, CA
- **Two terrestrial pilots (multiple sites)**
  - Forest treatment/fire risk reduction and fast-growth afforestation assessment in Lake County, OR (as part of an Oregon Solutions Project)
  - Forest treatment/fire risk reduction, native-species afforestation, and forest conservation management in Shasta County, CA



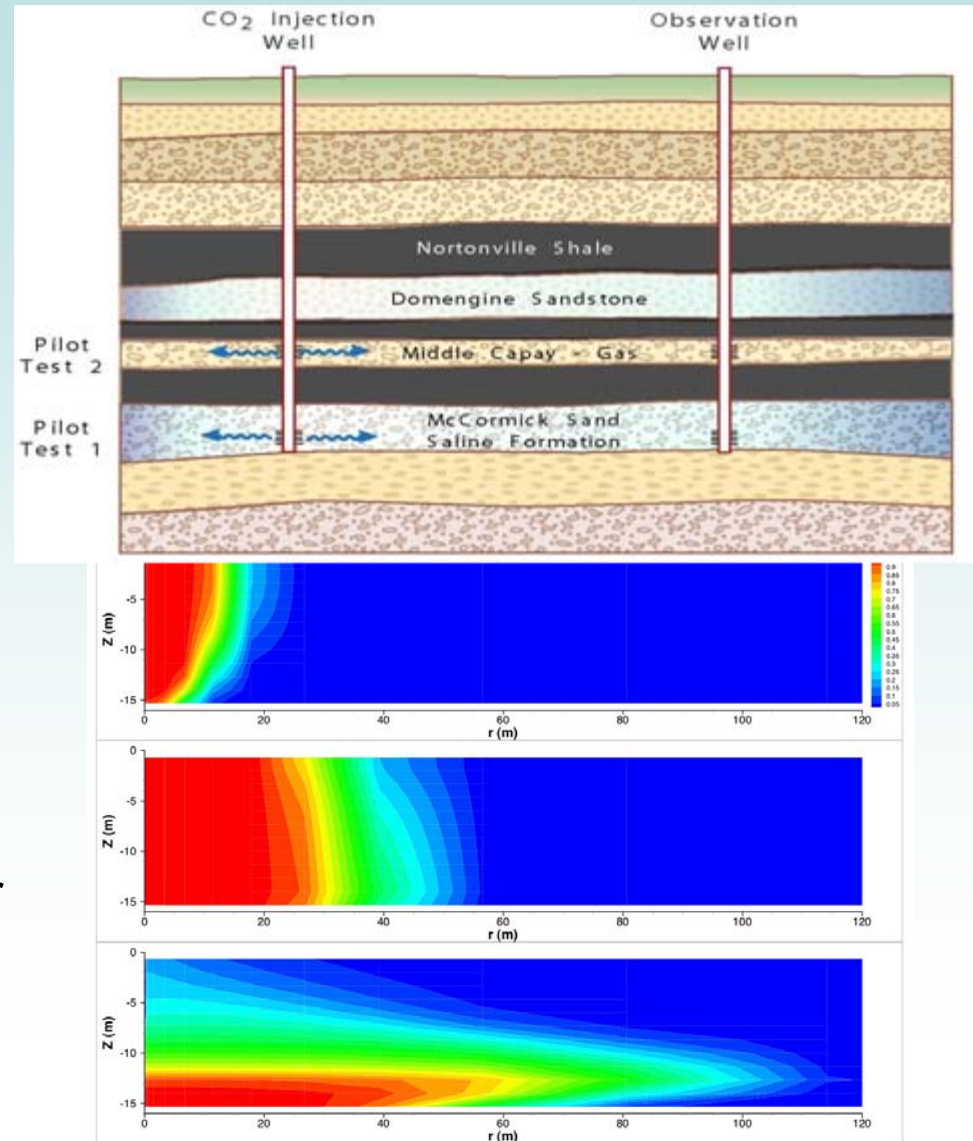
# Terrestrial Pilots are Underway

- Afforestation pilots underway in 5 locations in Shasta County, CA
- Baseline measurements/fuel treatments underway on PG&E, W M Beaty, and Latour Forest lands in Shasta County
- Baseline measurements/fuel treatments underway on Fremont-Winema National Forest, and Collins Co. lands in Lake County, OR



# Rosetta Pilot Progress

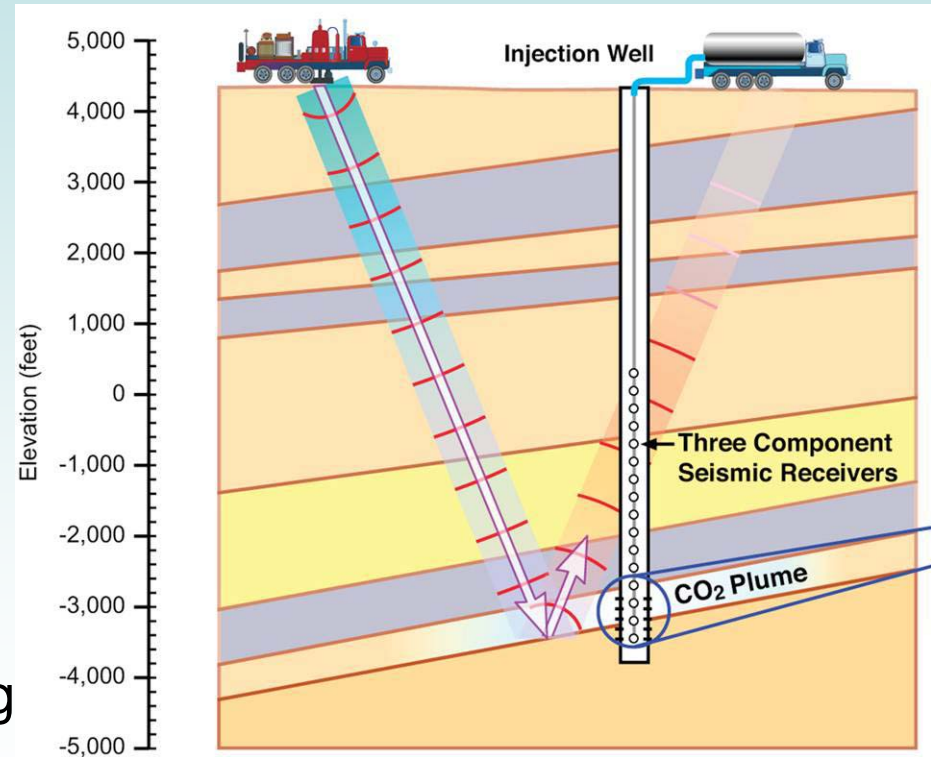
- NEPA and CEQA documentation completed
- Site manager selected
- Draft UIC permit submitted
- Agreement in principle on liability issues and property access
- Detailed field test plans finalized - informed by reservoir simulations
- Equipment purchased





# Arizona Utilities Pilot Status

- Salt River Project convened advisory committee of key stakeholders
- Permitting issues discussed with key Arizona agencies; preparation of permits underway
- Outreach to local land owners, Navajo Nation
- Detailed test planning now underway for scheduled testing in 2008; site manager selected



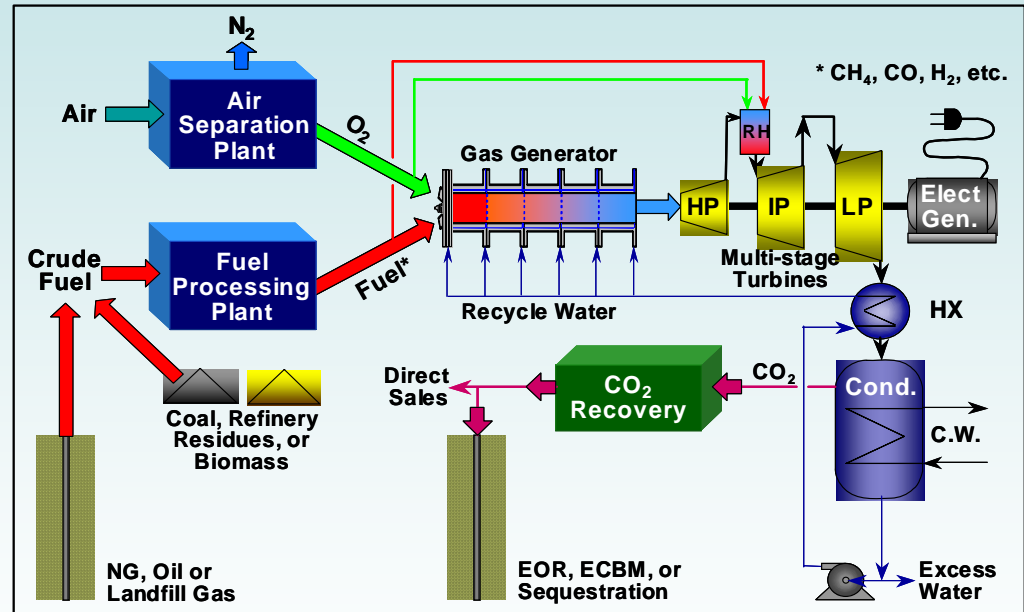
# Phase III WESTCARB Objectives

- Conduct a commercial scale CCS test in California
  - Accessing the best geologic target in the state
- Demonstrate advanced, commercial “sequestration -friendly” power generating technology (CES)
- Demonstrate commercial scale sequestration methodologies for site characterization and monitoring (Schlumberger)
- Conduct research supporting the subsurface sequestration methodologies, and advancing technologies in reservoir engineering, risk assessment, and monitoring
- Exercise, and provide important experience for, evolving regulatory and legal frameworks
- Establish in the public mind – via direct proof, that emission free fossil power is possible



# WESTCARB Phase III Test Developed From Phase II CES Site Characterization Pilot

- Lead industrial partners: Clean Energy Systems (CES), Schlumberger
- Research institutions: LBNL, Stanford, LLNL, and others
- CES is planning 49 MW power plant at Kimberlina, California
- Plant will provide 250,000 tons CO<sub>2</sub> per year for four years
- CO<sub>2</sub> injection testing in 2009; main injection to begin in Fall 2010



## CES power generating system

# First Generation Gas Generator



- Provides steam/CO<sub>2</sub> for 50 MW Power Plants
- Testing planned for 1Q 2008
- Same output as boiler below

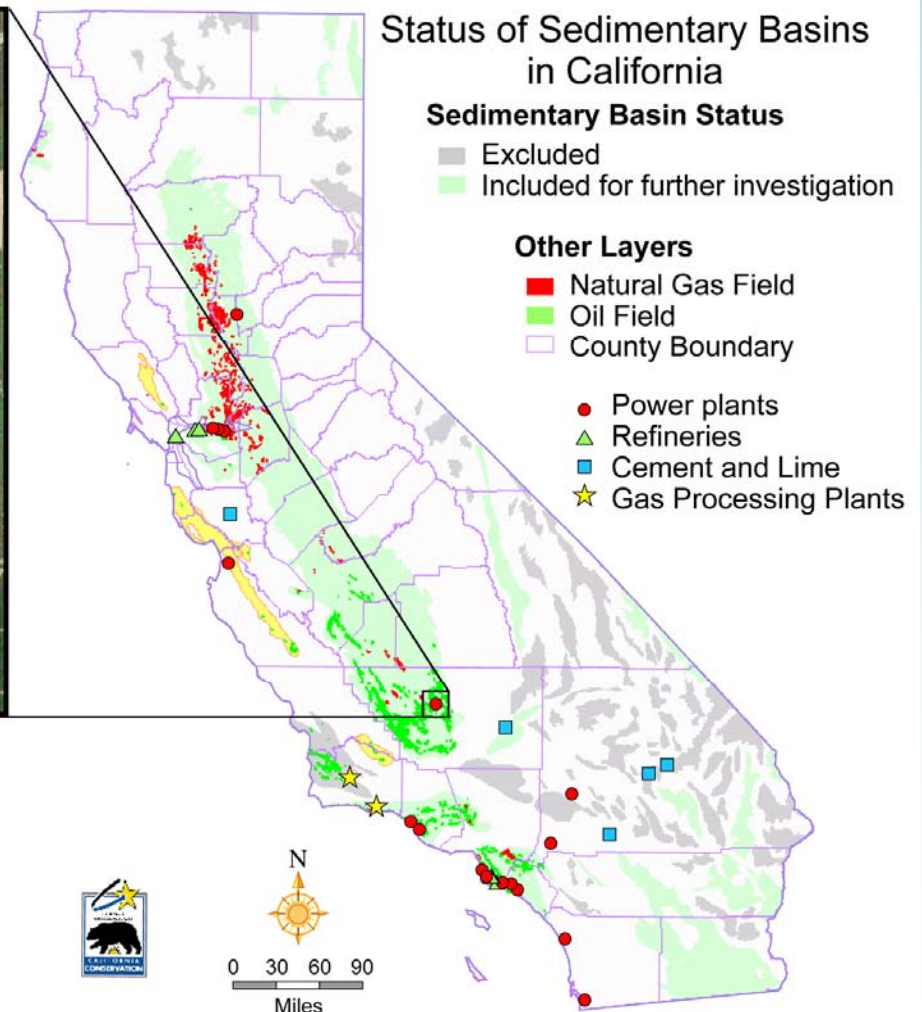
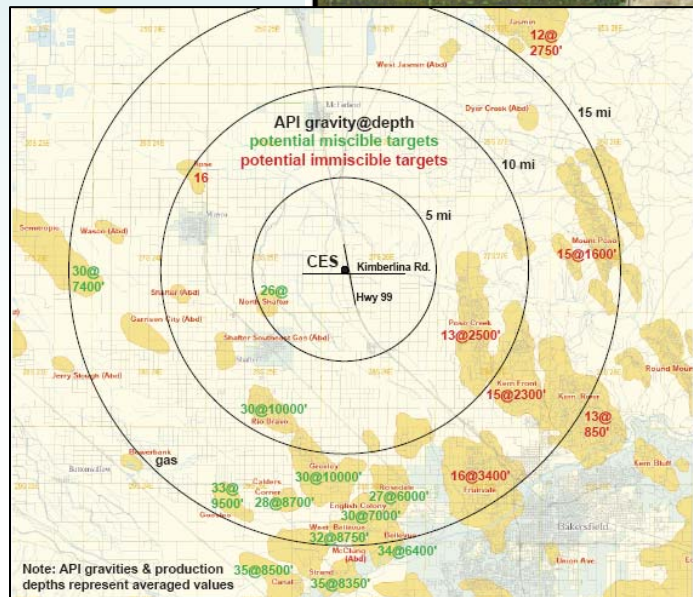
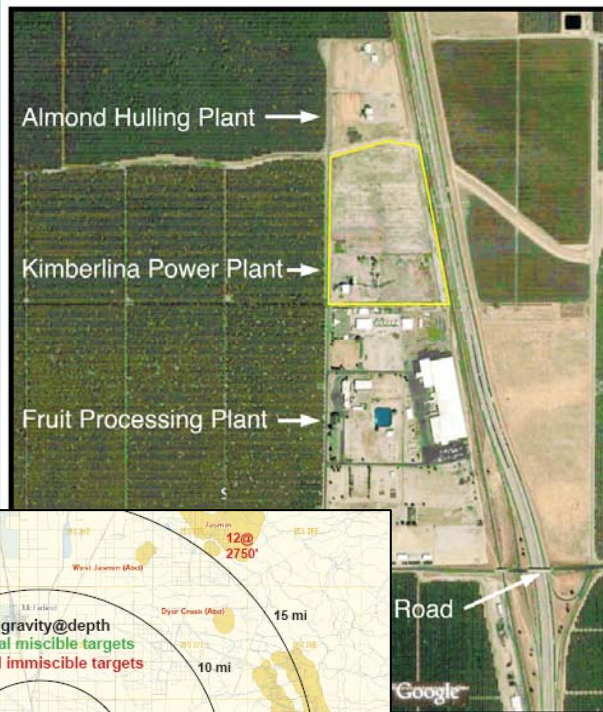


(Courtesy of CES)



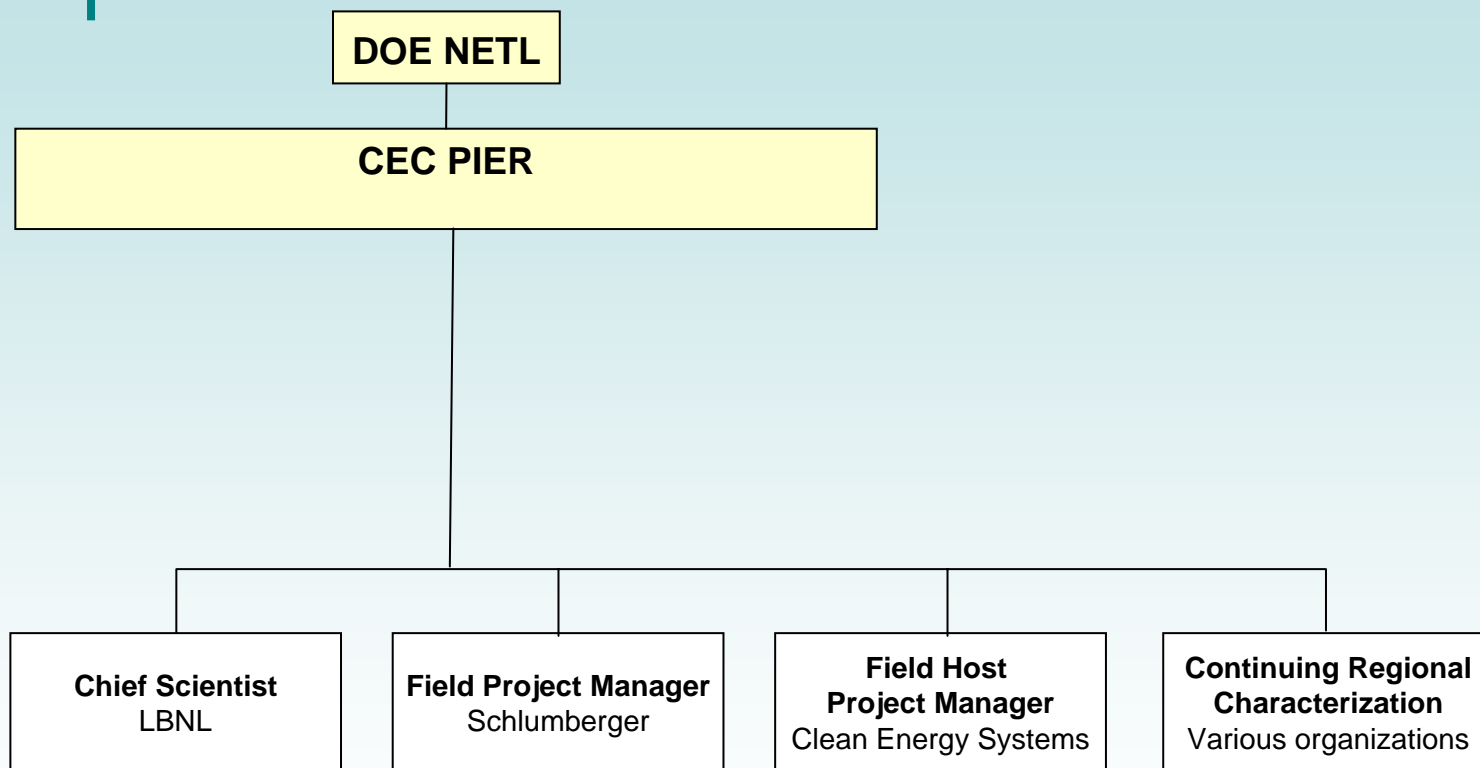


# Project Representative of Major CA Sequestration Potential

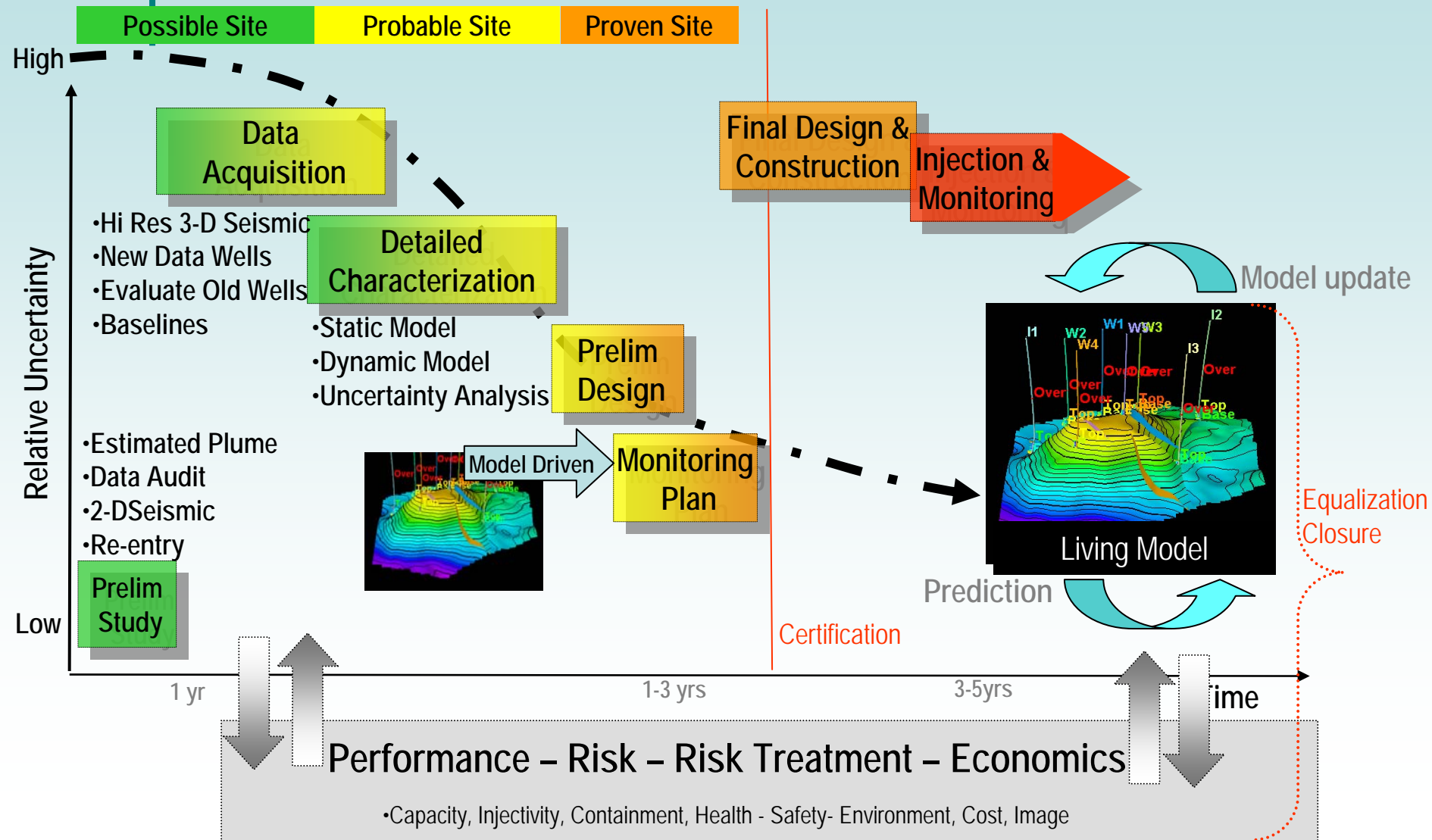




# WESTCARB Phase III Management Structure



# Developing a Commercial Project



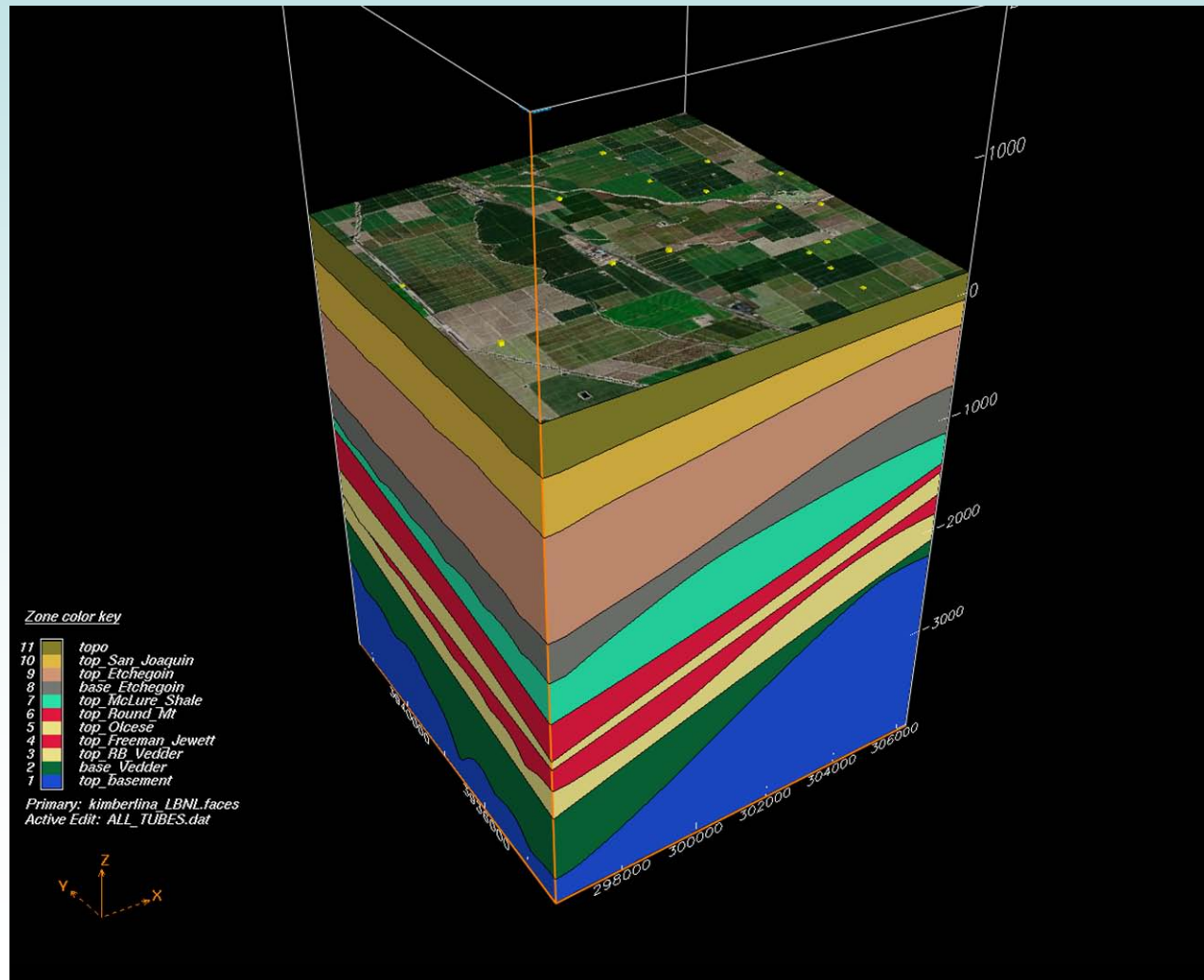
(Courtesy of Schlumberger)

# Basic Requirements for Siting and Permitting Must First be Met

- Site permits to operate a 49MW power plant (underway)
- Drilling and other permits for injection of carbon dioxide
- Additional work to better characterize site for injection
- Address sub-surface ownership and other potential impact issues
- Address environmental justice issues as they emerge
- Develop effective public outreach campaign



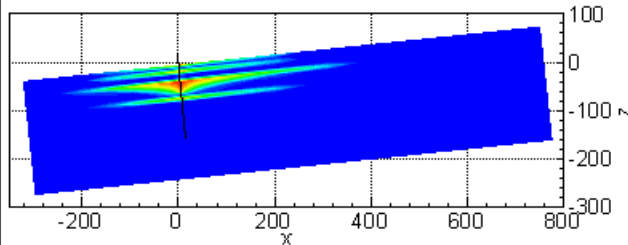
# Initial Geologic Model Based on Available Well Data



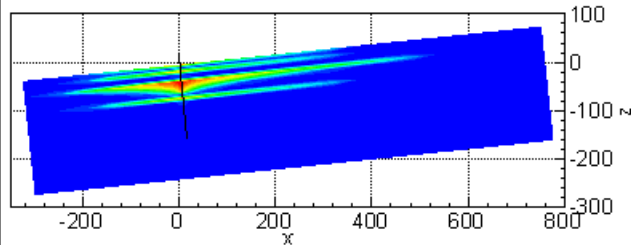
(From J Wagoner,  
LLNL)

# Olcese Injection

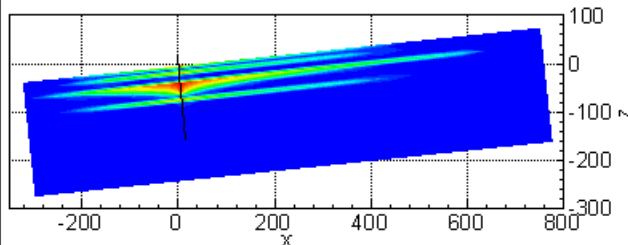
1 year



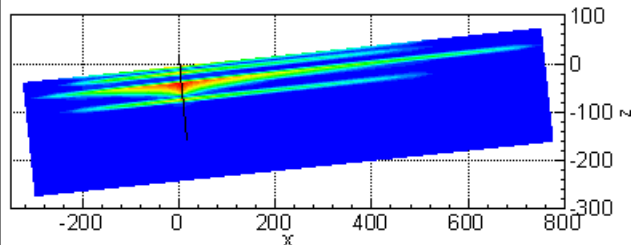
2 years



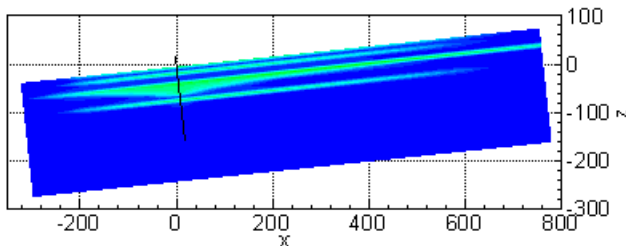
3 years



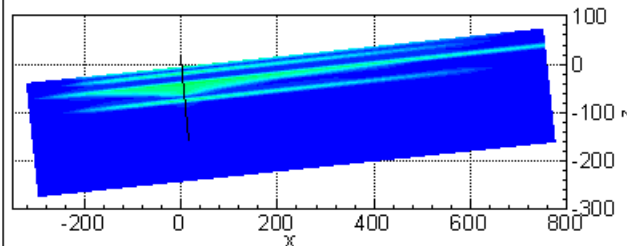
4 years  
End Injection



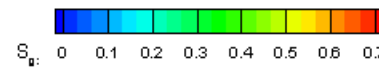
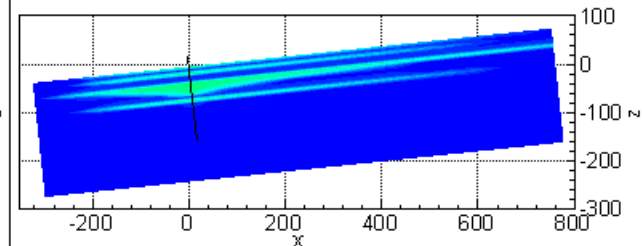
7 years



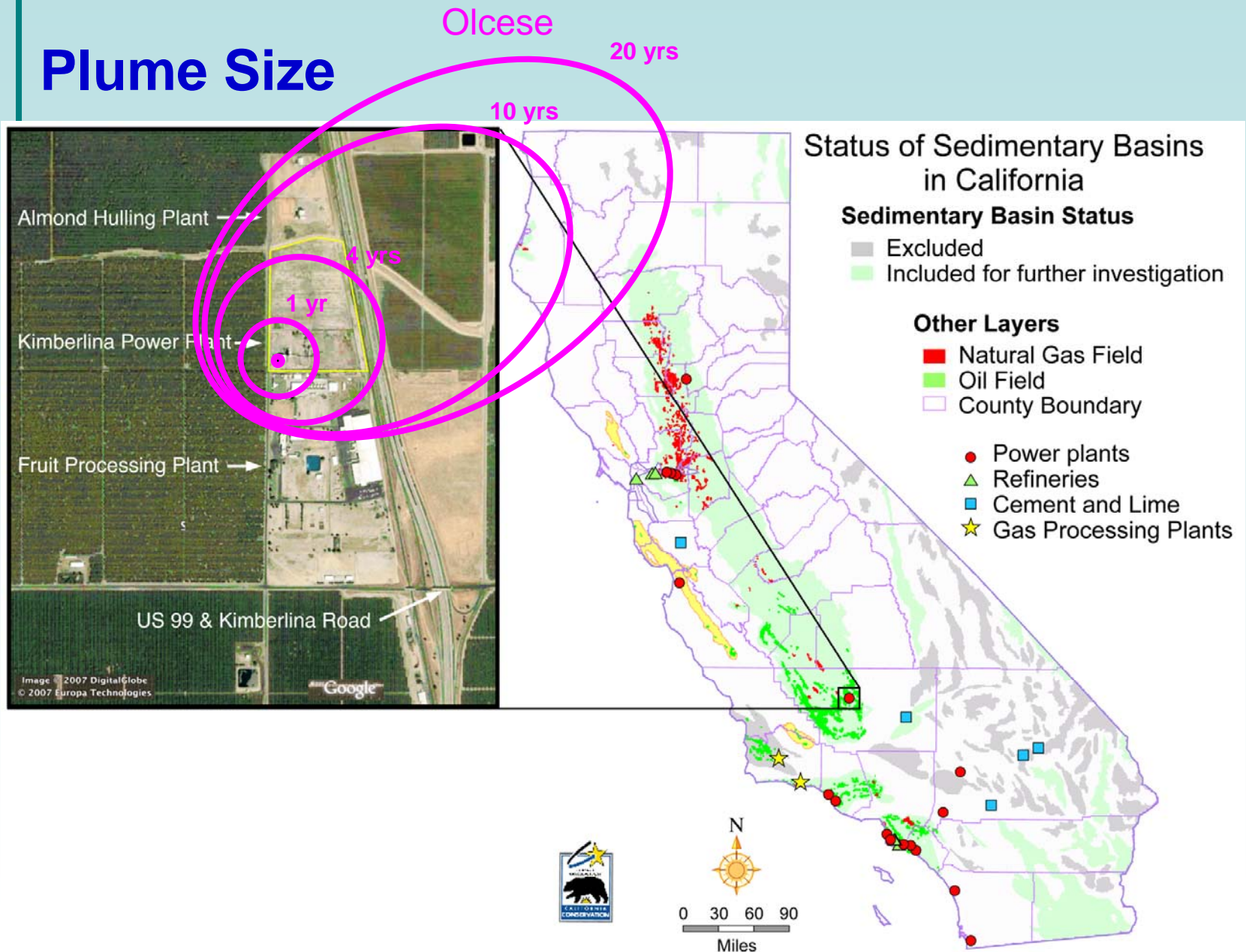
10 years



20 years



# Plume Size





# WESTCARB Phase III Monitoring Program

## Pre-Operational Monitoring

- Well logs and cores
- Wellhead pressure
- Formation P, T, fluids
- Injection rate & pressure
- 3D seismic survey; VSP
- Atmospheric CO<sub>2</sub> monitoring
- CO<sub>2</sub> flux monitoring
- Pressure and water quality above the storage formation
- Microseismic monitoring

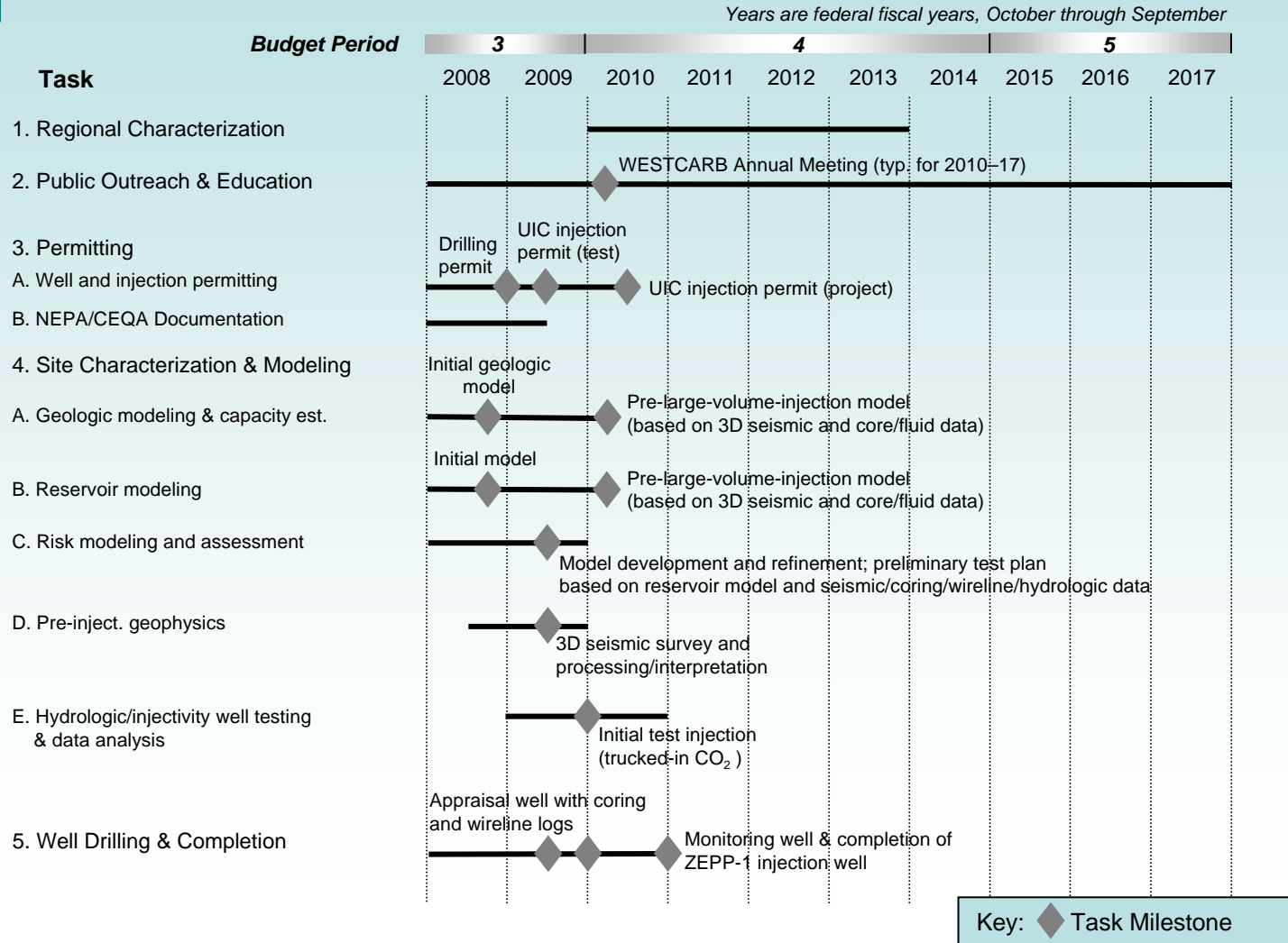
## Operational Monitoring

- Well logs
- Wellhead pressure
- Formation P, T, fluids
- Annulus pressure
- Injection rate & pressure
- 3D seismic survey
- Atmospheric CO<sub>2</sub> monitoring
- CO<sub>2</sub> flux monitoring
- Pressure and water quality above the storage formation
- Microseismic monitoring
- Active source thermal logging
- PSInSAR

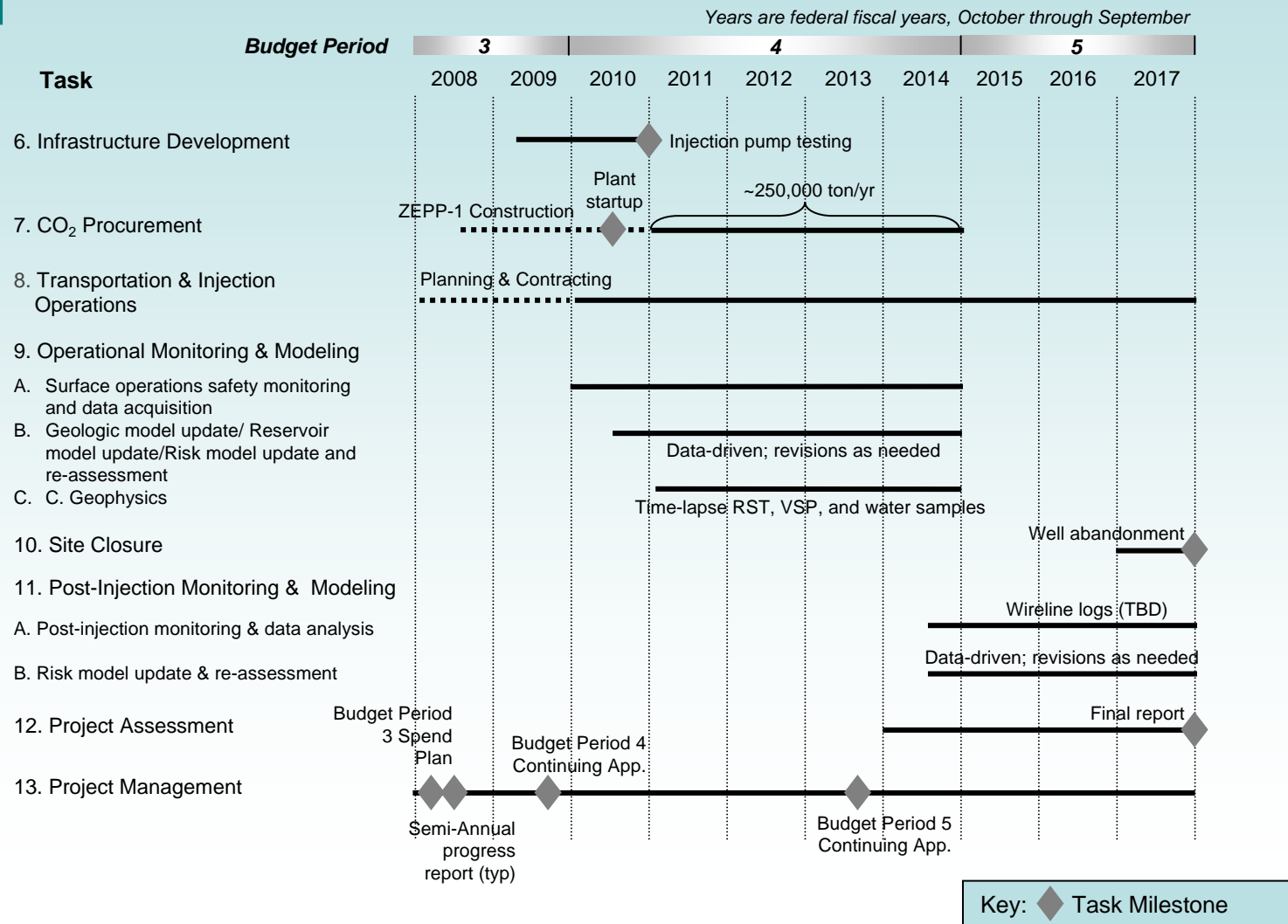
## Post-Injection Monitoring

- Well logs
- CO<sub>2</sub> flux monitoring
- Formation P, T, fluids
- Pressure and water quality above the storage formation
- 3D seismic survey
- PSInSAR

# WESTCARB Phase III Project Schedule

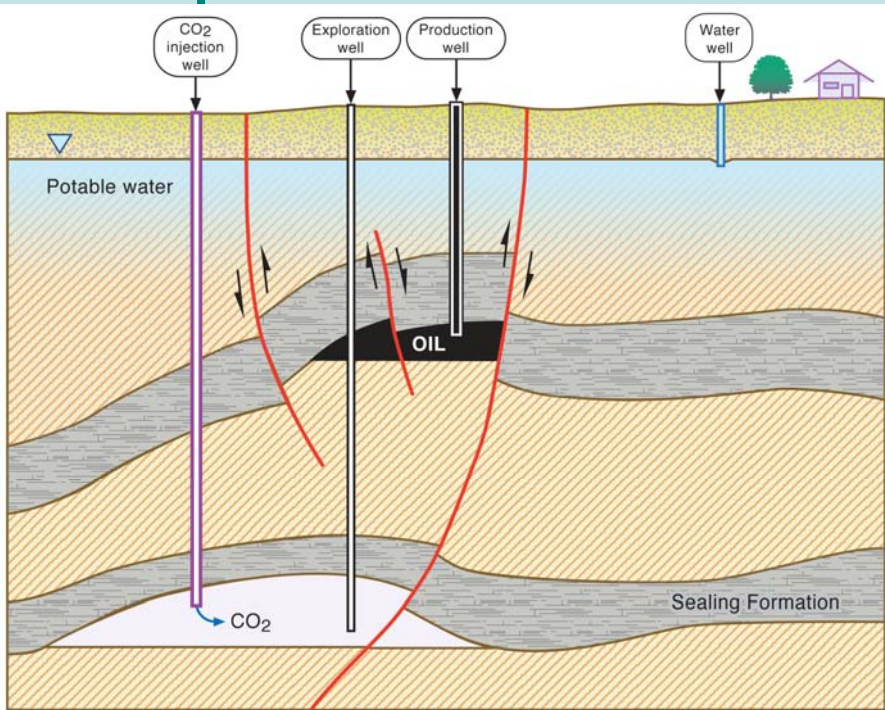


# WESTCARB Phase III Project Schedule (cont'd)

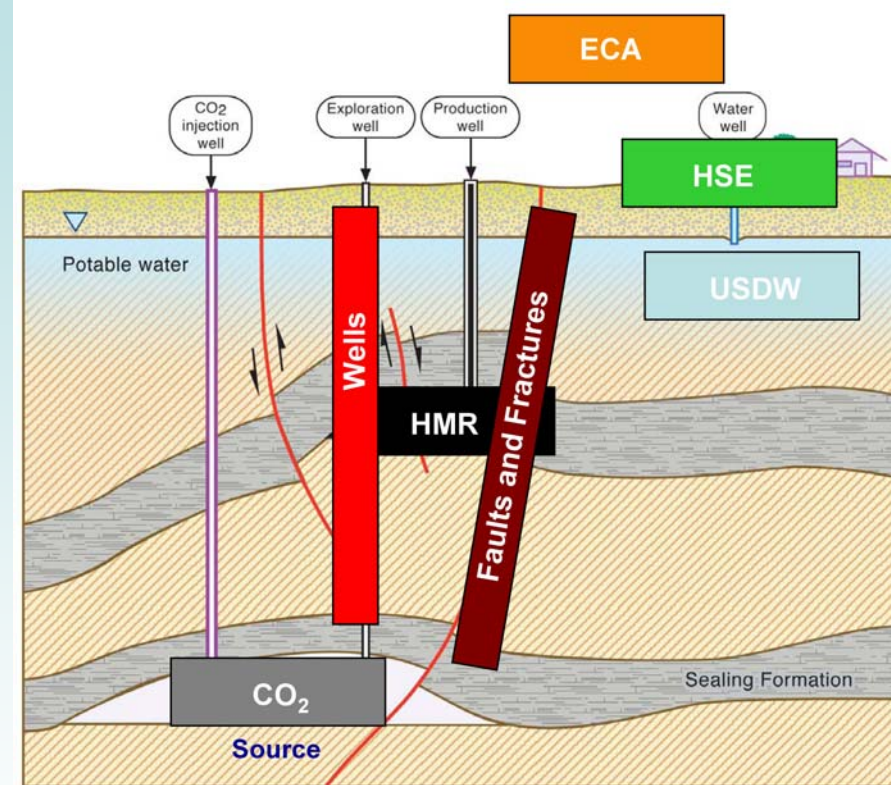




# CCP2 Risk Analyses Will Be Applied



Four compartments vulnerable to impacts:  
ECA = Emission Credits and Atmosphere  
HSE = Health, Safety, and Environment  
USDW = Underground Sources of Drinking Water  
HMR = Hydrocarbon and Mineral Resources

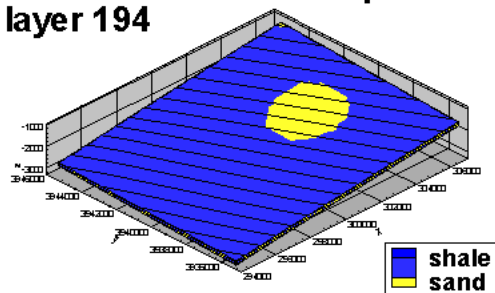


Two conduits with potential for leakage:  
Wells, Faults and Fractures  
*CO<sub>2</sub> Leakage Risk is probability that Negative impacts will occur to HMR, USDA, HSE, or ECA due to CO<sub>2</sub> migration*

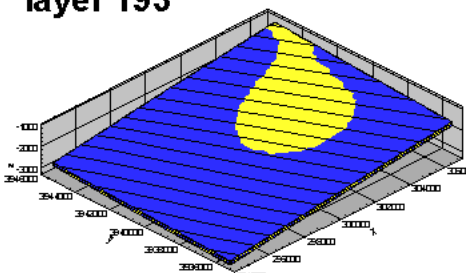
(From C Oldenburg, LBNL)

# Initial 600 layer Sand-Shale Model for Olcese and Vedder

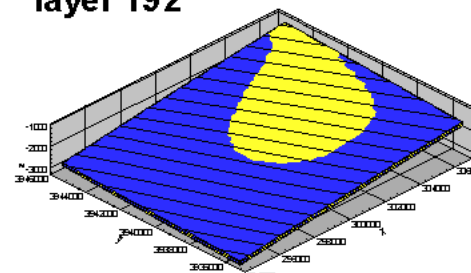
EarthVision Model: Top Vedder layer 194



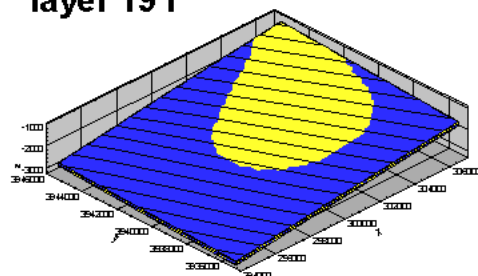
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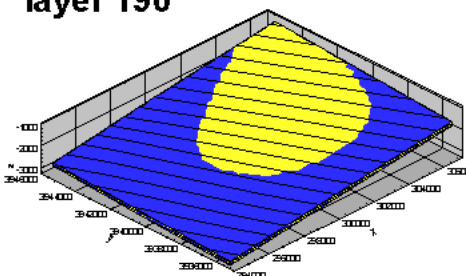
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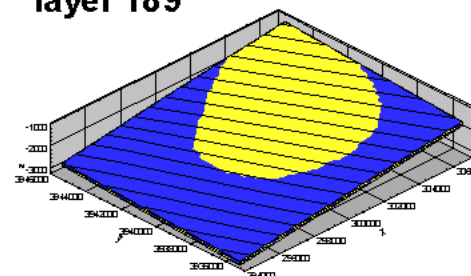
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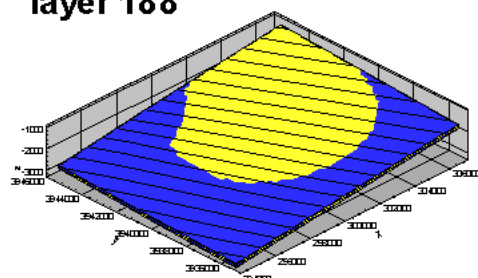
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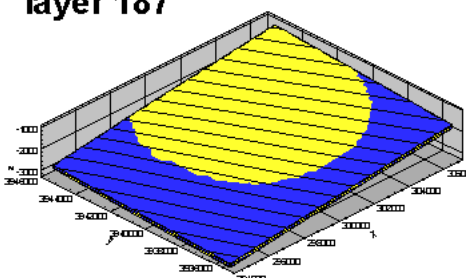
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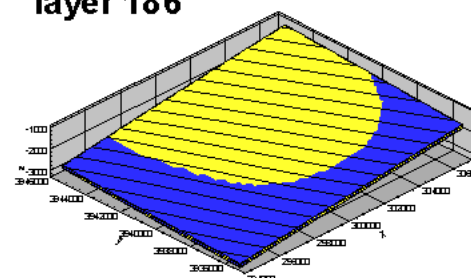
layer 188



layer 187



layer 186



(From J Waggoner, LLNL)

# Schematic Overview of Monitoring Program

